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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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09/820,694

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06/09/2004

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EXAMINER

MALDONADO, JULIO J

ART UNIT

PAPER NUMBER

2823

DATE MAILED: 06/09/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

09/820,694

Applicant(s)

ZHU ET AL.

Examiner

Julio J. Maldonado

Art Unit

2823

-- **Th MAILING DATE of this communication appears on th cover sheet with the correspondence address --**

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 19 March 2004.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1,2,4-7,9,11-17,19-22 and 24-29 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1,2,4-7,9,11-17,19-22 and 24-29 is/are rejected.
- 7) ☒ Claim(s) 1 and 24 is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
Paper No(s)/Mail Date _____.
- 4) ☐ Interview Summary (PTO-413)
Paper No(s)/Mail Date. _____.
- 5) ☐ Notice of Informal Patent Application (PTO-152)
- 6) ☐ Other: _____.

DETAILED ACTION

1. The cancellation of claims 3, 8, 10, 18 and 23 is acknowledged.
2. Claims 1, 2, 4-7, 9, 11-17, 19-22 and 24-29 are pending in the application.

Continued Examination Under 37 CFR 1.114

3. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 03/19/2004 has been entered.

Claim Objections

4. Claims 1 and 24 are objected to because of the following informalities: the claims do not require a particular plasma density through use of "medium density plasma" because the term does not have an accepted meaning in the art and has not been defined in the instant specification. Appropriate correction is required.

Claim Rejections - 35 USC § 103

5. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

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6. Claims 1, 2, 4, 6, 7, 11-15, 19-22, 24, 27, 28 and 29 rejected under 35 U.S.C. 103(a) as being unpatentable over the Applicants Admitted Prior Art in view of Kadomura (U.S. 4,654,114) and Long et al. (U.S. 2003/0079983 A1).

In reference to claims 1, 2, 4, 6, 11, 12, 20-22, 24, 28 and 29, the prior art teaches providing a substrate having a layer of silicon nitride and the silicon nitride having an underlying and/or overlying dielectric layer comprising silicon oxide or a low-k dielectric material; introducing the substrate into a plasma reactor; and plasma etching the silicon nitride layer, forming openings in the silicon nitride layer (Instant pages 2-3).

The prior art fails to teach etching the silicon nitride layer using a parallel plate plasma reactor; supplying etching gas to the plasma etching reactor and energizing the etching gas into a plasma state, the etching gas including CH_3F and at least one oxygen reactant supplied to the plasma etching reactor at a flow rate ratio of oxygen reactant to CH_3F of 0.65 to 1.5; and etching exposed portion of the silicon nitride layer with the plasma while providing an etch rate selectivity the etching rate of the silicon nitride layer to the etching rate of the dielectric layer of at least about 10. However, Kadomura in a related method to selectively plasma etching a silicon nitride layer over a silicon oxide layer teaches etching the silicon nitride layer using a parallel plate plasma reactor; supplying etching gas to the plasma etching reactor and energizing the etching gas into a plasma state, the etching gas including CH_3F and at least one oxygen reactant supplied to the plasma etching reactor and is nitrogen-free; and etching exposed portion of the silicon nitride layer with the plasma while providing an etch rate selectivity the etching rate of the silicon nitride layer to the etching rate of the dielectric layer, wherein

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the etching rate of the oxide varies according the amount of etching gases in the reactor (column 2, line 46 – column 4, line 55).

It would have been within the scope of one of ordinary skill in the art to combine the teachings of the prior art and Kadomura to enable the etching step of the prior art to be performed according to the teachings of Kadomura because one of ordinary skill in the art at the time the invention was made would have been motivated to look to alternative suitable methods of performing the disclosed etching step of the prior art and art recognized suitability for an intended purpose has been recognized to be motivation to combine. MPEP 2144.07.

The combined teachings of the prior art and Kadomura fail to teach wherein the plasma reactor is a medium plasma density plasma reactor, wherein the plasma reactor comprises a dual frequency parallel plate plasma reactor having a showerhead electrode and a bottom electrode on which the substrate is supported, the bottom electrode being supplied RF energy at two different frequencies or the showerhead electrode being supplied RF energy at a first frequency and the bottom electrode being supplied RF energy at a second frequency which is greater than the first frequency. However, Long et al. (Figs.1a-f) teach a capacitively coupled plasma etching reactor comprising a dual frequency parallel plate plasma reactor having a showerhead electrode and a bottom electrode on which a substrate is supported, the showerhead electrode being supplied RF energy at a first frequency and the bottom electrode being supplied RF energy at a second frequency, wherein the plasma density is adjustable ([0002] – [0003], [0027], [0029], [0043] and [0045]).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to combine the teachings of the prior art, Kadomura and Long et al. to enable the etching process of the prior art and Kadomura in the etching reactor of Long et al., and furthermore because this would provide better uniformity of the etched layer (Long et al., [0010]). It would also have been obvious to one of ordinary skill in the art to adjust the control parameters of Long et al. to enable controlled plasma density conditions.

The combined teachings of the prior art and Kadomura and Long et al. fail to teach wherein the showerhead electrode is supplied with an RF energy at a first frequency and the bottom electrode is supplied at an RF energy at a second frequency which is greater than the first frequency; wherein the flow rate ratio of oxygen reactant to CH_3F of 0.65 to 1.5, wherein the etching rate of the silicon nitride layer to the etching rate of the dielectric layer is at least about 10, wherein the flow rate of the oxygen reactant to fluorocarbon reactant is 1 or less, wherein the fluorocarbon reactant is supplied to the plasma reactor at a flow rate of 5 to 200 sccm and the oxygen reactant is supplied to the plasma reactor at a flow rate of 5 to 200 sccm, wherein the bottom electrode is maintained at a temperature of 20 to 50° during the etching step, and wherein the plasma reactor pressure is at a pressure above 80 mTorr . However, the selection of the above mentioned etching parameters is obvious because it is a matter of determining optimum process condition by routine experimentation with a limited number of species to obtain desired etching conditions. Therefore, it would have been

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obvious to one of ordinary skill in the art at the time the invention was made to use the above-mentioned range to arrive at the claimed invention.

In reference to claim 7, the combined teachings of the prior art, Kadomura and Long et al. substantially teach all aspects of the invention but fail to disclose wherein the openings are 0.25 micron or smaller sized openings and/or wide open trenches. Notwithstanding, it would have been an obvious matter of design choice bounded by well known manufacturing constraints and ascertainable by routine experimentation and optimization to choose these particular dimensions because applicant has not disclosed that the dimensions are for a particular unobvious purpose, produce an unexpected result, or are otherwise critical, and it appears prima facie that the process would possess utility using another dimension. Indeed, it has been held that mere dimensional limitations are prima facie obvious absent a disclosure that the limitations are for a particular unobvious purpose, produce an unexpected result, or are otherwise critical. See, for example, *In re Rose*, 220 F.2d 459, 105 USPQ 237 (CCPA 1955); *In re Rinehart*, 531 F.2d 1048, 189 USPQ 143 (CCPA 1976); *Gardner v. TEC Systems, Inc.*, 725 F.2d 1338, 220 USPQ 777 (Fed. Cir. 1984), cert. denied, 469 U.S. 830, 225 USPQ 232 (1984); *In re Dailey*, 357 F.2d 669, 149 USPQ 47 (CCPA 1966).

In reference to claim 13, the combined teachings of the prior art, Kadomura and Long et al. teach applying an RF bias to the semiconductor substrate during the etching step (Long et al., [0004]).

In reference to claim 14, the combined teachings of the prior art, Kadomura and Long et al. teach wherein the silicon nitride layer overlies an electrically conductive comprising copper (Instant page 2, lines 3 – 13).

In reference to claim 15, the combined teachings of the prior art, Kadomura and Long et al. teach wherein the etching step is carried out as part of a process of manufacturing a damascene structure (Instant page 2, lines 3 – 13).

In reference to claim 17, the combined teachings of the prior art, Kadomura and Long et al. teach wherein the silicon nitride layer is between an overlying dielectric layer and an underlying copper layer, the copper layer being exposed to the plasma in the openings during the etching step (Instant page 2, lines 3 – 13).

In reference to claims 19 and 27, the combined teachings of the prior art, Kadomura and Long et al. teach wherein the plasma reactor is at a pressure of about 38 mTorr during the etching step (Kadomura, column 4, lines 37 – 39). The prior art of record fails to teach wherein the plasma reactor is at a pressure of 5 to 1,000mTorr during the etching step. However, in the case where the claimed ranges “overlap or lie inside ranges disclosed by the prior art” a prima facie case of obviousness exists. MPEP 2144.05. Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the pressure disclosed in the combined teachings of the prior art, Kadomura, Long et al. to arrive at the claimed invention. Still, the prior art of record fails to teach wherein the semiconductor substrate is supported on a bottom electrode maintained at a temperature of 20 to 500 °C during the etching step. However, the selection of the claimed temperature is obvious because it is a matter of

determining optimum process condition by routine experimentation with a limited number of species to obtain desired etching conditions. Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the above-mentioned temperature to arrive at the claimed invention.

7. Claims 5, 9 25 and 26 are rejected under 35 U.S.C. 103(a) as being unpatentable over the Applicants Admitted Prior Art in view of Kadomura (U.S. 4,654,114) and Long et al. (U.S. 2003/0079983 A1) as applied to claims 1, 2, 4, 6, 7, 11-15, 19-22, 24, 27, 28 and 29 above, and further in view of Hung et al. (U.S. 6,380,096 B2).

The combined teachings of the prior art, Kadomura and Long et al. teach wherein adding oxygen to the etching prevents the formation of polymers (column 3, lines 34 – 42), but fail to teach wherein the etching gas consists of CH_3F , oxygen and optionally Ar, and further teaching forming a photoresist layer as a masking layer, patterning the photoresist layer to form a plurality of the openings and the etching step forms a via or contact openings in the silicon nitride layer. However, Hung et al. (Figs.5-10) in a related method to selectively plasma etch a silicon nitride layer (12, 16) teach an etching gas consists of CH_3F , oxygen and optionally Ar, and further teaching forming a photoresist layer (98, 118) as a masking layer, patterning the photoresist layer (98, 118) to form a plurality of the openings (18, 22) and the etching step forms a via or contact openings (18, 22) in the silicon nitride layer (12, 16) (column 11, line 48 – column 12, line 67). It would have been within the scope of one of ordinary skill in the art to combine the teachings of Kadomura and Long et al. with the teachings of Hung et al. to

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enable the etching step of Kadomura and Long et al. to be performed according to the teachings of Hung et al. because one of ordinary skill in the art at the time the invention was made would have been motivated to look to alternative suitable methods of performing the disclosed etching step of Kadomura and Long et al. and art recognized suitability for an intended purpose has been recognized to be motivation to combine.

MPEP 2144.07.

Response to Arguments

8. Applicant's arguments with respect to claims 1, 2, 4-7, 9, 11-17, 19-22 and 24-29 have been considered but are moot in view of the new ground(s) of rejection.

Conclusion

9. Any inquiry of a general nature or relating to the status of this application should be directed to the Group Receptionist whose telephone number is 571-272-2800. See MPEP 203.08.

10. Any inquiry concerning this communication or earlier communications from the examiner should be directed to examiner Julio J. Maldonado whose telephone number is (571) 272-1864. The examiner can normally be reached on Monday through Friday.

11. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Olik Chaudhuri, can be reached on (571) 272-1855. The fax number for this group is 703-872-9306 for before final submissions, 703-872-9306 for after final submissions and the customer service number for group 2800 is (703) 306-3329.

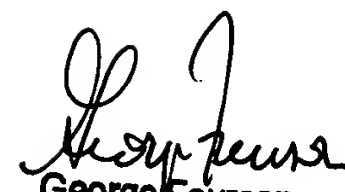
Updates can be found at <http://www.uspto.gov/web/info/2800.htm>.

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Julio J. Maldonado
Patent Examiner
Art Unit 2823

Julio J. Maldonado
June 1, 2004


George Fourson
Primary Examiner